The case for UK power flex investment

Briefing pack

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TIMERA ENERGY

Timera Energy
Level 12
30 Crown Place
London EC2A 4ES

timera-energy.com
+44 (0) 207 965 4541

Contents

Key takeaways

UK needs flex investment

Sharpened focus on flex

- Covid recovery plans are accelerating the energy transition across Europe, reinforced by net-zero targets and energy policy response to the Ukraine crisis.
- The UK has gone a step further with a net zero 2035 power sector target.
- However extreme UK power price volatility & system stress events in 2021 have highlighted the requirement for major investment in flexible capacity.
- This briefing pack focuses on flex asset value drivers in two sections: (A) market drivers & (B) investment case drivers.

5 key takeaways

Takeaway	Description
1. Policy momentum	Policy action is accelerating the need for flexible capacity to support renewable rollout & decarbonisation.
2. Flex deficit	Thermal closures set to outpace renewables growth, driving a flex capacity deficit (of at least 30GW by 2035).
3. Demand growth	Flex requirement is compounded by demand growth given decarbonisation of other sectors (transport, heat).
4. Flex returns	Changes in UK capacity mix and demand are set to structurally support flexible asset returns.
5. Investment	Large investment needed in low carbon flex capacity to enable decarbonisation (at least £30-40 bn by 2035).

A. Market & policy drivers

Policy focus shifting to flex

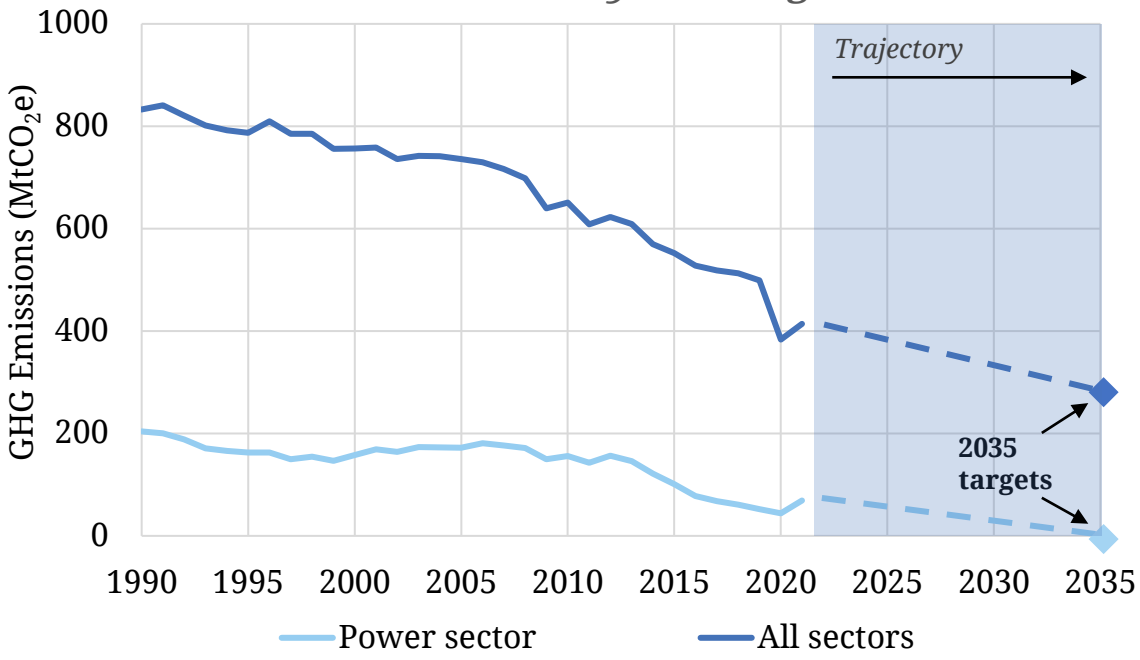
Accelerating policy momentum

- UK is leading Europe's push to decarbonise, with an ambitious goal to decarbonise power by 2035.
- This is a structural policy shift focused on environment, economy, jobs, affordability & inequality (e.g. Northern Powerhouse).
- Effective renewable policy support is already in place & scaling.
- The policy focus is now shifting to flexibility… supported by the current acute flex deficit & market volatility.

Why is flexibility key?

- Decarbonisation requires large flex capacity investment to support:
    1. Rapid growth in intermittent output swings
    2. Decarbonisation of current flexible fossil capacity
    3. Large demand growth as other sectors decarbonise
    4. Alleviation of network stress through the transition.

UK GHG emissions history and targets



**Note: 2020 emissions data affected by COVID-19 pandemic*

Headline UK policy targets

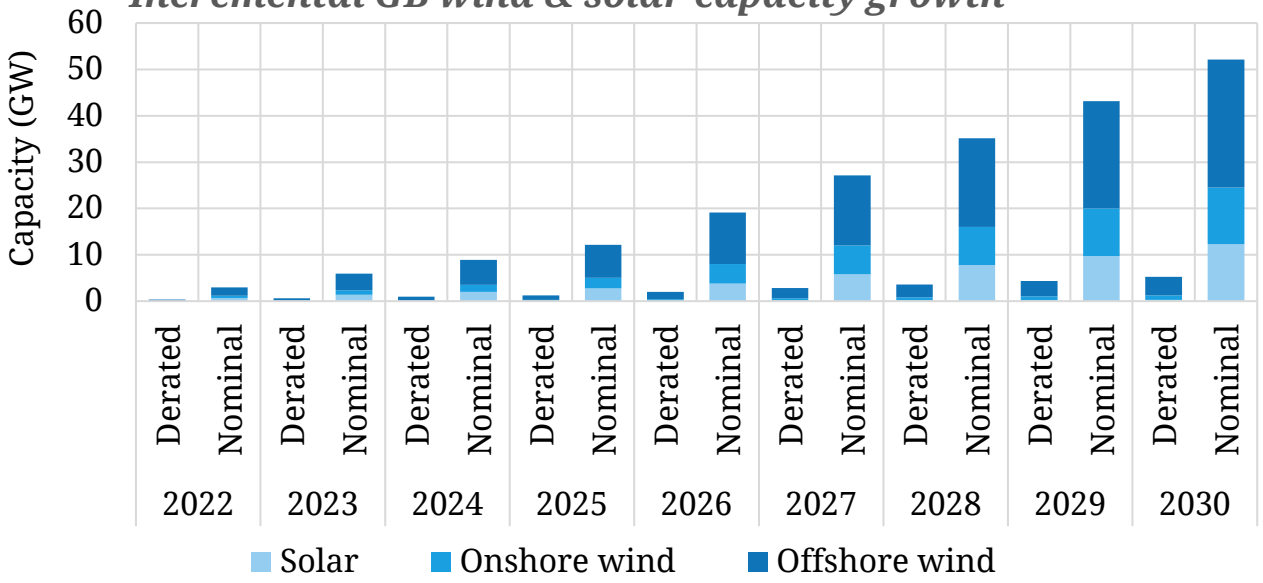
Sector	Target
Total GHG emissions	78% reduction by 2035
Power sector emissions	100% reduction by 2035
Offshore wind	40GW by 2030
Electrolysers	5GW by 2030

Renewables build is accelerating

Rapid renewables growth led by wind…

- Recent increases in policy targets are set to drive an acceleration in wind & solar capacity.
- But security of supply standards across Europe are defined based on derated capacity and wind & solar contributions are low.

Incremental GB wind & solar capacity growth



Source: Timera Energy, national targets, UK government Capacity Market derating factors

… means system needs to manage huge swings

- By 2030, UK renewable output set to swing by up to 40GW intraday, against a projected peak demand of ~75GW.
- As renewable output grows so do system balancing requirements, underpinning an ongoing need for new flex.

RES output intraday swing distributions (GW)

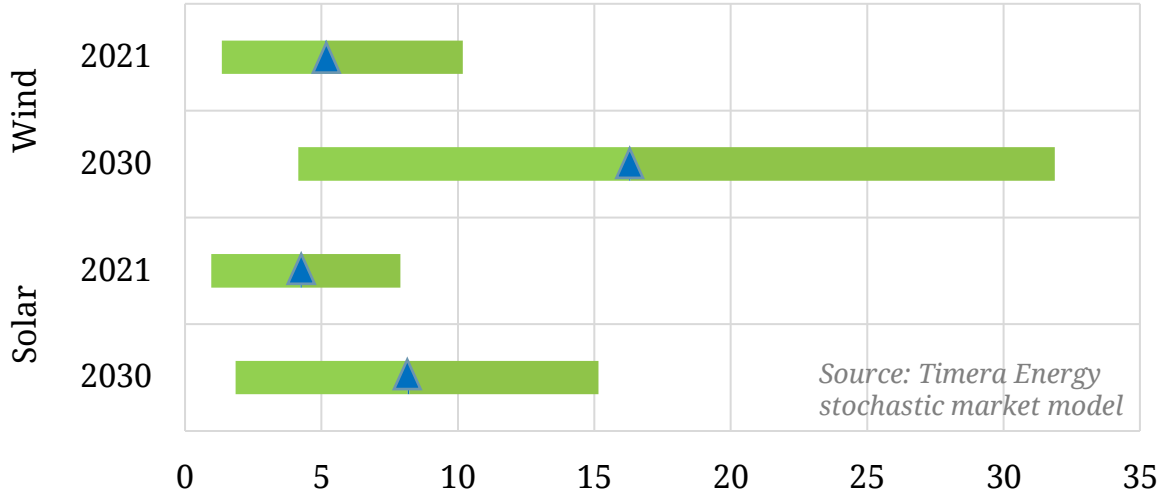


Chart shows intraday swing ranges (5% - 95%) of wind & solar output. Wind swing is larger and much less predictable than solar.

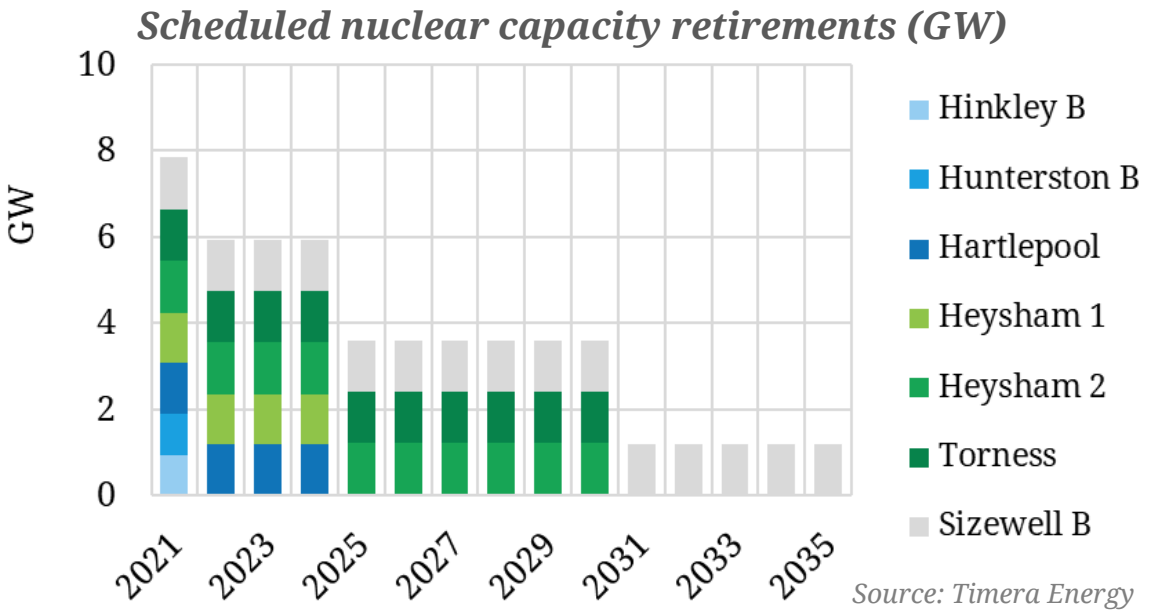
Thermal closures are happening faster

Ageing thermal capacity closures accelerating

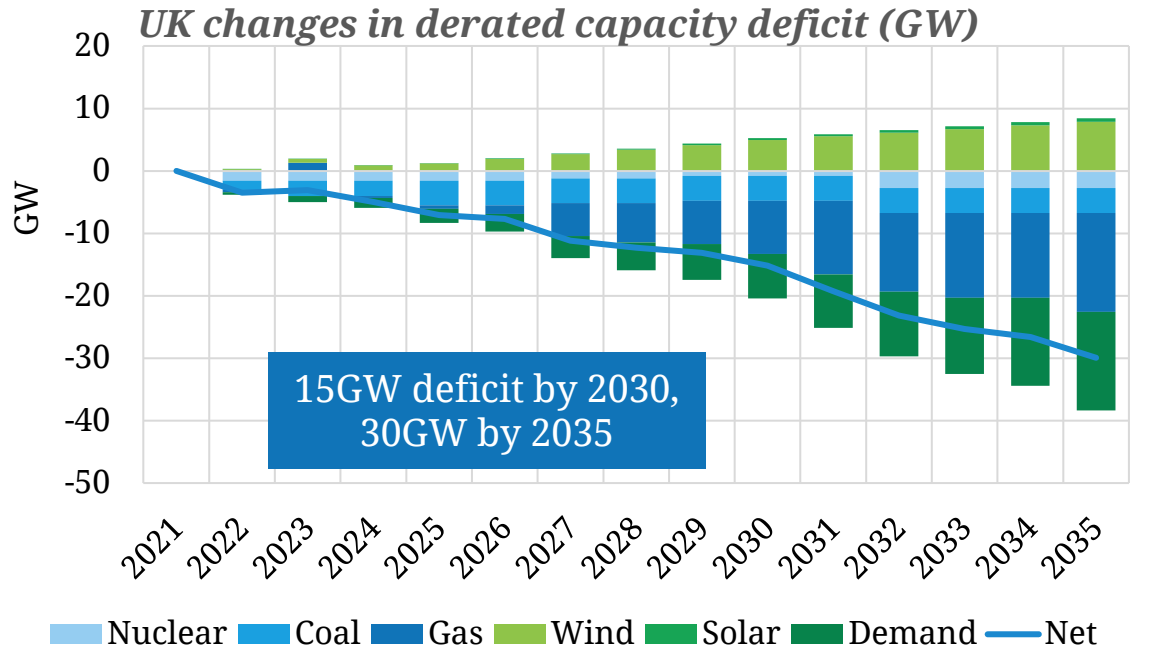
- UK is retiring coal, nuclear & gas capacity faster than it is building renewable capacity on a derated basis:
  - Existing nuclear capacity to fall 5GW by 2030, with new nuclear beset by delays.
  - Final 4GW of coal to close by 2025. At least 15GW of ageing gas capacity needs repowering or major capex by 2035.

A flex deficit is emerging… and fast

- Around 15GW flex deficit by 2030, and 30GW by 2035, with £30-40 bn new flex investment required.
- In addition to new-build capacity another 14-17GW of residual gas capacity will require decarbonising to achieve net-zero by 2035. Options include:
  - CCGT + CCUS: high CAPEX, likely limited to industrial clusters
  - Hydrogen: likely focused on peaking engines given lower cost conversion & v high fuel costs.
  - Residual gas: unabated gas dealt with temporarily via offsets.



Source: Timera Energy



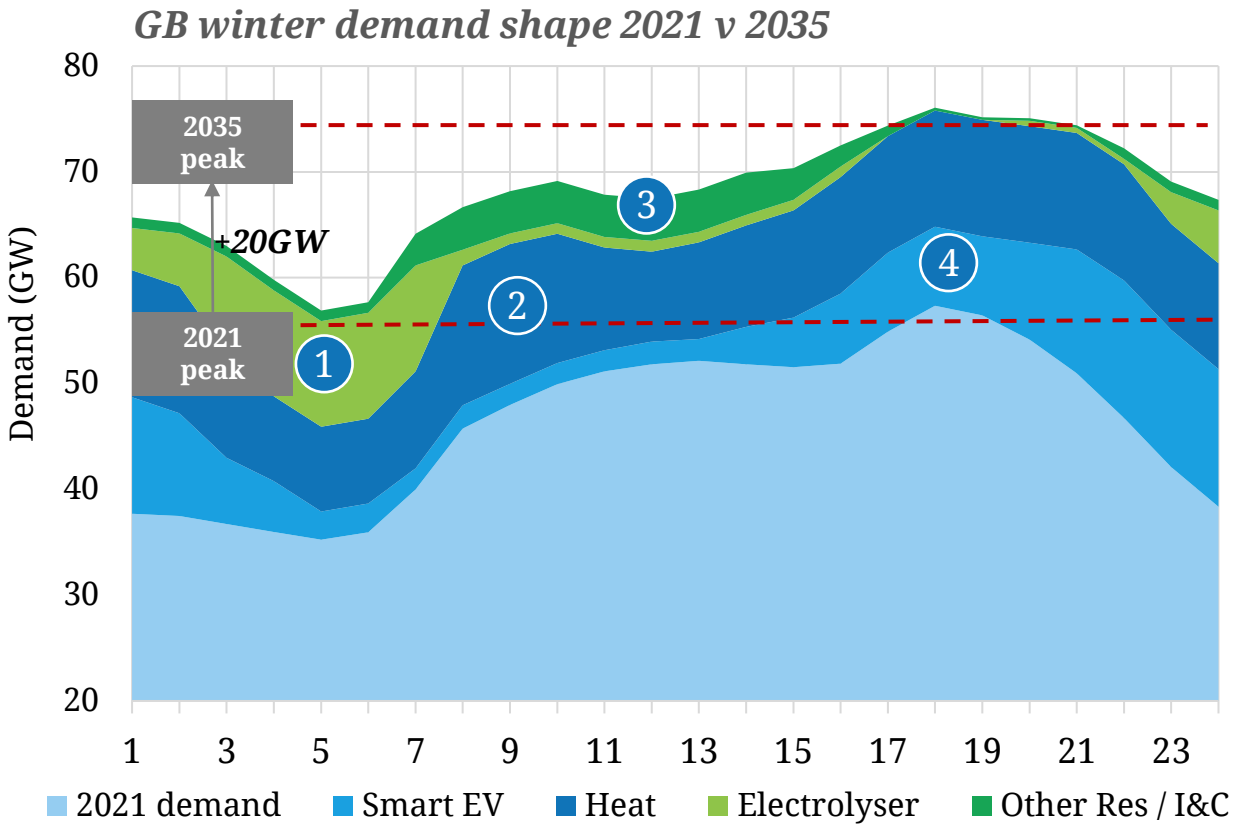
**Note: Rising peak demand increases the requirement for firm capacity and increases capacity deficit. Our demand growth assumptions are conservative compared to Gov targets.*

Demand growth also set to accelerate

Electrification to drive structural growth

- Net zero requires electrification of transport, heat & industry.
- By 2035, power demand may be 30-50% higher than 2021.
- Demand is set to become smarter & more flexible, but within major distribution network constraints.

	Driver	2035 demand evolution
1	Electrolysers	• Price sensitive, very flexible but minimum run requirements • Overnight demand up by 10GW+
2	Residential heating	• Largely price insensitive, limited flex • Annual demand + 30TWh, peak demand up by an extra 12GW+
3	Other Res / I&C	• Increased electrification of industrial processes supports demand • Price sensitive
4	EV	• Charging profile based on combo of consumer habit and smart charging • Peak demand up by 8GW+



Source: Timera Energy, CCC, FES, DNO data

Chart shows GB power demand across a cold winter day in 2021. Projected incremental increases for 2035 are overlaid. Chart illustrates drivers of changes in demand shape.

Major transition in capacity mix

Structural shift in price setting dynamics

- 30GW of CCGTs at similar variable cost levels have historically (i) dominated UK price setting & (ii) dampened price volatility.
- As CCGTs, coal & nuclear close, capacity is being replaced by:
  - High variable cost peaking capacity e.g. batteries, peakers, DSR.
  - Low variable cost & intermittent wind & solar capacity.
- The chart shows these changes drive an increasing incidence of:
  - High prices set by peaking capacity
  - Low prices set by wind & solar capacity.

Increase in requirement for system flex

- Flex capacity will be key to support system transition:
  - Renewable curtailment set to grow rapidly as constraints bind & grid infrastructure fails to keep pace with wind & solar
  - Increase in balancing services (e.g. frequency, inertia) required to manage decarbonising power mix
  - Lack of spinning CCGT reserve will require rapid flex up & down to manage short notice fluctuations.

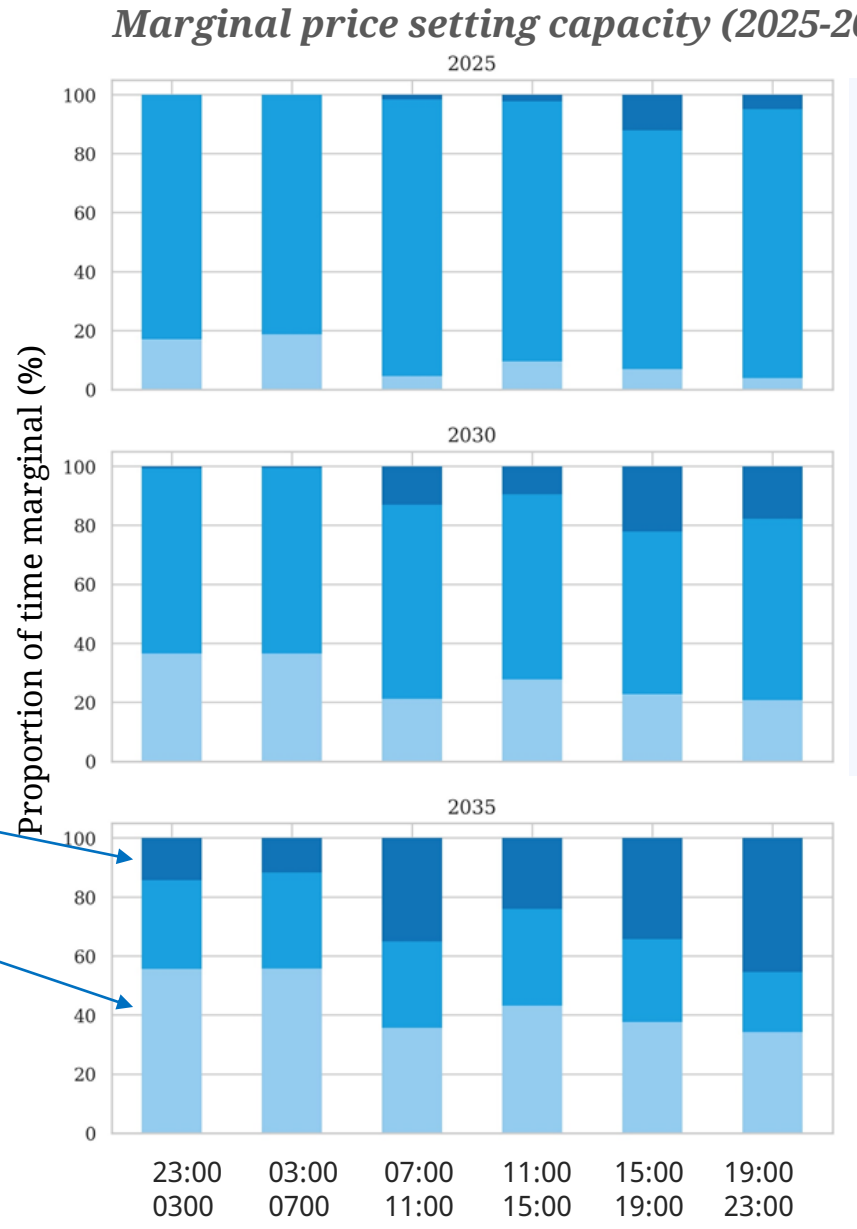


Chart shows the % of time different technology types set GB power prices across winter (2025 - 35).

In 2025, CCGTs dominate price setting, but with the impact of wind, solar & peakers growing rapidly.

By 2035, more than 70% of prices set by:
(i) high SRMC peakers and storage
(ii) low SRMC renewables

Source: Timera Energy stochastic market model

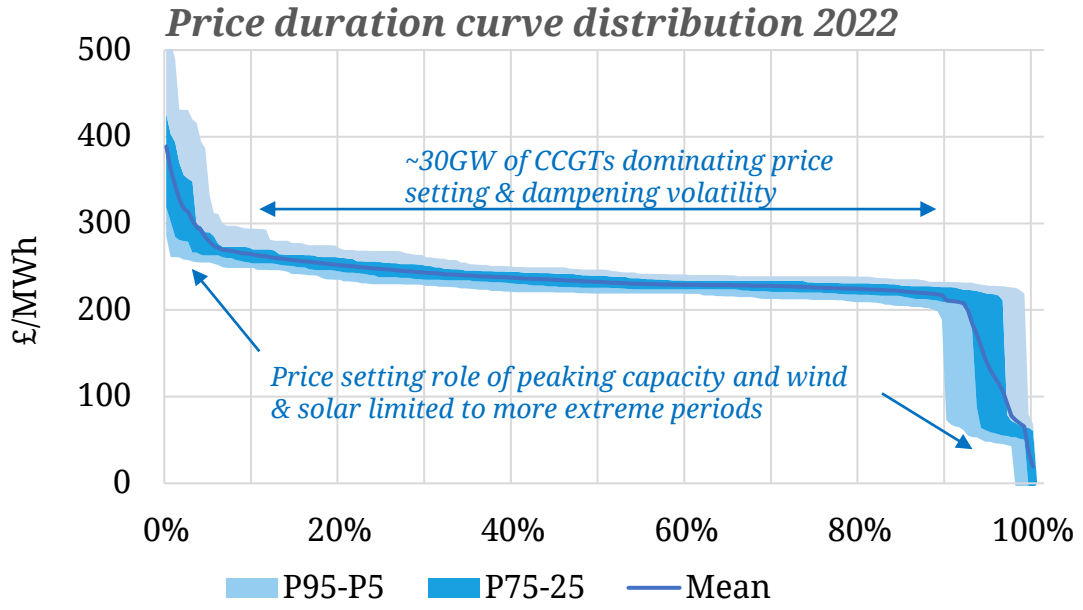
Structural rise in flex asset price signals

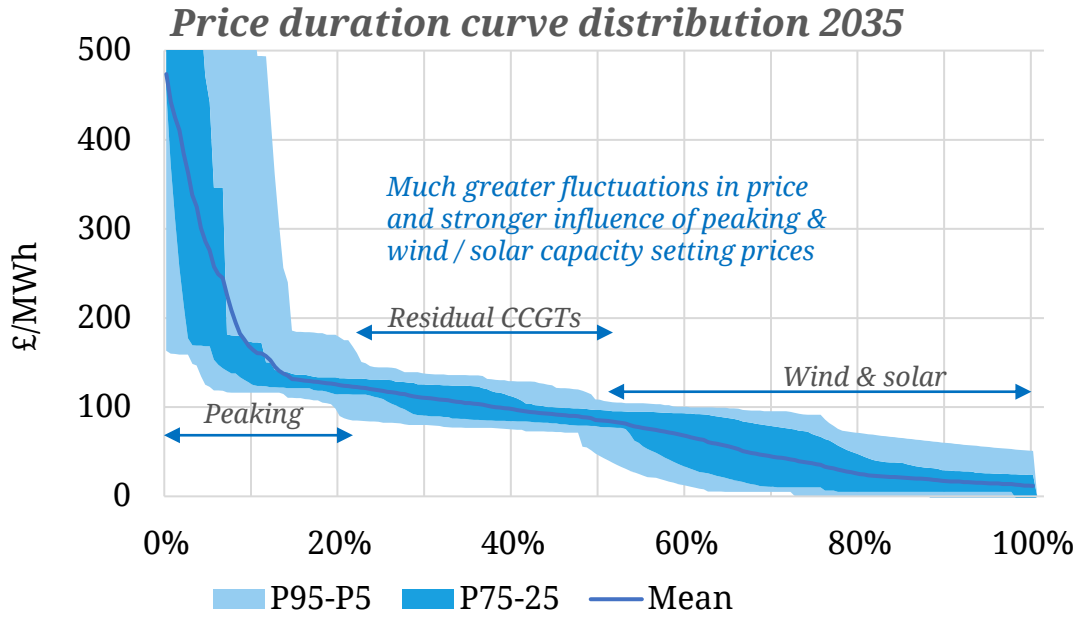
Transition driving up price shape & volatility

- Charts show illustrative power price duration curve distributions from Timera's stochastic power market model (2022 vs 2035).
- By 2035 there is a much greater:
  1. distribution of pricing outcomes (i.e. higher volatility)
  2. role of peaking capacity setting high prices
  3. role of wind & solar capacity setting low prices.
- Capacity mix changes & rising demand are underpinning a structural increase in price shape & volatility.

Market price signals for flex investment

- Flex assets (e.g. batteries, peakers, DSR & electrolysers) 'harvest' price shape & volatility to generate returns.
- Energy market returns are supported by capacity & balancing services payments.
- The accelerating pace of decarbonisation is providing structural tailwinds for flexible asset returns.



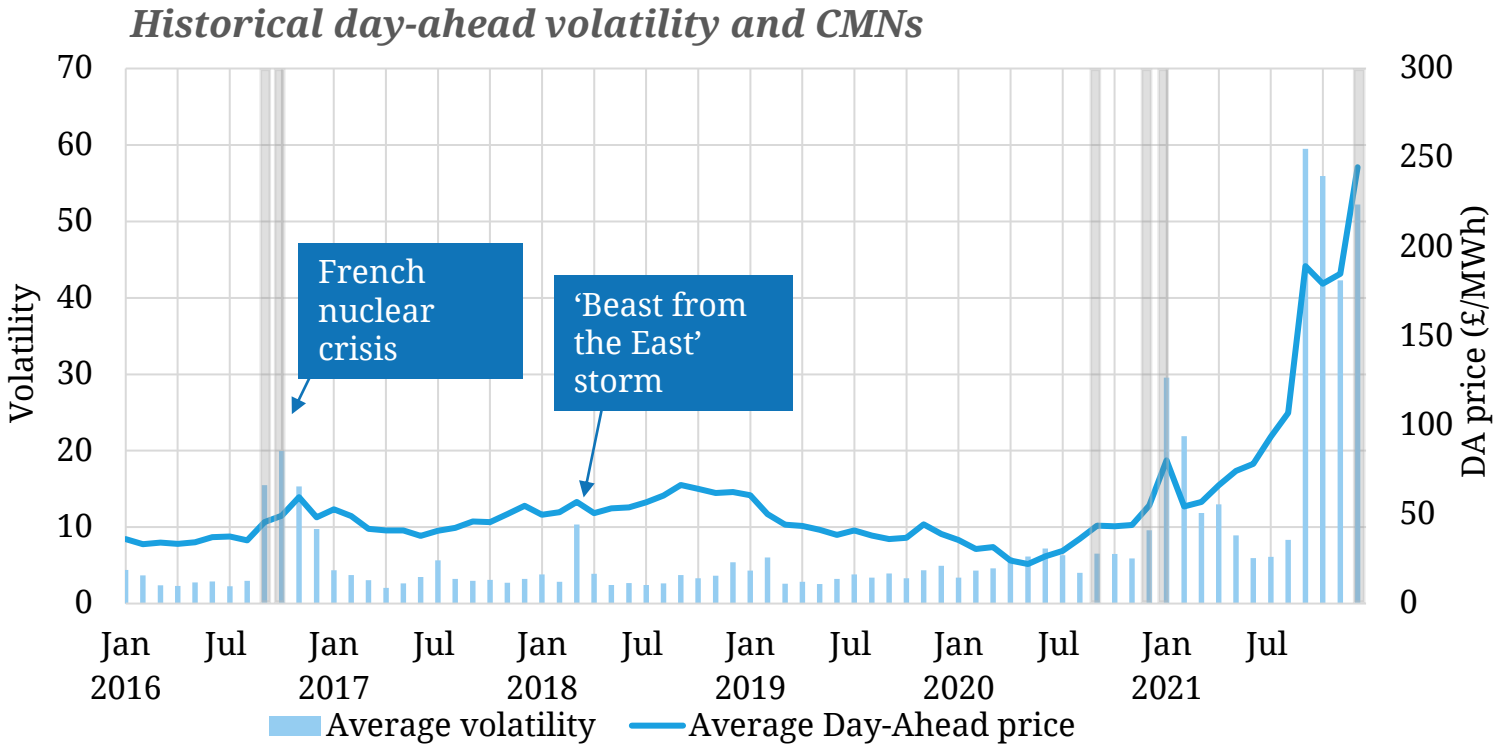


Source: Timera Energy stochastic market model

Evidence from extreme volatility across 2021-22

Market prices signalling a need for flex… now

- Acute market tightness across Winter 2021-22 driven by ageing gas & nuclear plant outages, adverse wind conditions & interconnector flows and system constraints.
- As system margins tighten, frequency of Capacity Market Notices (CMN) has increased significantly (grey bars in chart).
- Flex assets returns have surged with system stress and price volatility, ramping to meet periods of insufficient supply and rapidly re-optimising once prices fall.
- 2021-22 market dynamics and flex asset returns are providing clear evidence of the requirement for flex asset investment now.



Grey bars on the above chart indicate Capacity Market Notices which have increased significantly in frequency since 2020.

Source: Timera Energy

B. Flex investment case drivers

Visualising the role of flex capacity 1

Low wind and solar day highlights requirement for flex

- By 2030, GB is set to have over 90GW of wind & solar, but periods of low wind and solar will still leave significant gaps for flexibility.
- The chart shows a typical low wind & solar day in 2021, with generation scaled up to reflect 2030 capacities against 2021 demand.
- Even considering the huge increase in renewable capacity, with demand at approximately 800GWh and renewable generation 50GWh, a flex requirement of 750GWh emerges.

Load shifting flex alone is not enough

- By 2030, battery storage capacity is projected to be ~10GW, with 20-40GWh of storage, well short of the 750GWh of required flex.
- Interconnectors are unlikely to meet renewable shortfalls as wind & solar conditions are heavily correlated across neighbouring markets.

Long duration flex is needed

- Large energy deficits cannot be met by storage alone.
- Storage & DSR can temporarily shift / balance energy but are net consumers. Interconnectors can relocate but not create energy.
- That leaves a key role for long duration flexibility.

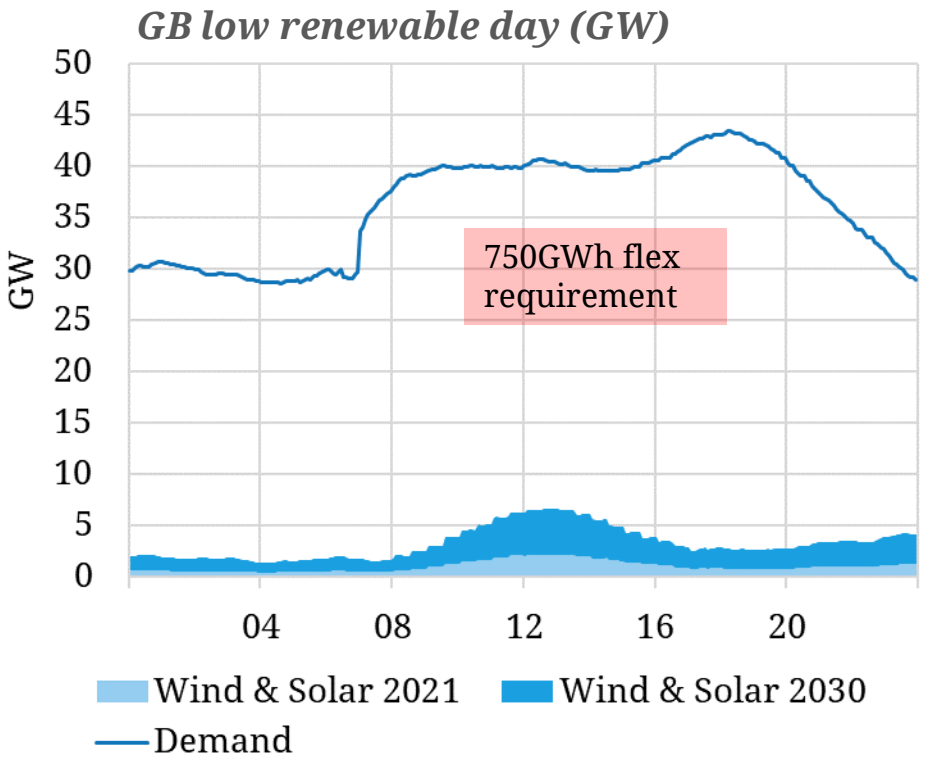


Chart shows demand profile vs renewables output for a recent GB market day (2021). Even with a more than doubling of renewable capacity, over 750GWh of additional firm flexible generation required across one day.

Source: ENTSOE, Timera Energy

Visualising the role of flex capacity 2

Weekly swings in wind to reach 3TWh by 2030

- Periods of low wind and solar are not confined to isolated hours or days… they can span weeks.
- In the chart opposite we show the average weekly load factors for GB wind in 2021:
  - Q1 weekly load factors averaged ~30% (and a max of 42%)
  - Load factors as low as 8% in some weeks, with weekly output drops of almost 1TWh.
- By 2030, weekly swing may reach 3 TWh as wind capacity grows.

Long duration flex key for decarbonisation

- Projected battery storage capacity of 20-40GWh (~10GW) in 2030 falls well short of requirements to service this swing.
- Periods of low wind & solar output are currently met by gas, coal & nuclear plants, most of which are set to retire by early 2030s.
- A low carbon longer duration flex solution to back up wind & solar swings remains a key challenge to enable decarbonisation.
- Competition to provide a solution covers e.g. long duration storage, electrolysers, CCGT + CCUS, hydrogen peakers, & interconnectors.

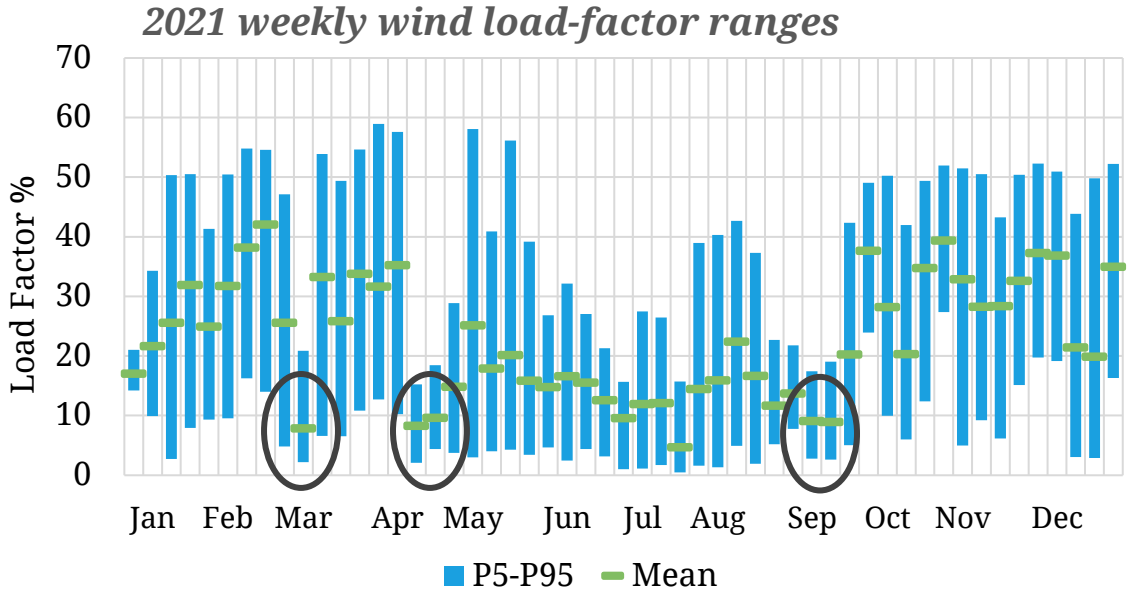


Chart highlights the (i) mean and (ii) P5-P95 range of loadfactors across weeks of 2021. Weekly loadfactors frequently fall significantly below average levels across both the summer and winter, with extended periods of back-up thermal generation required. Long duration flexibility is required to fill these gaps.

Source: ENTSOE, Timera Energy

What type of flex does GB need to decarbonise?

4 key types of flexibility are required to support decarbonisation

Flexibility type	Description
1. Capacity (MW)	Flex to meet residual demand peaks (load – wind – solar)
2. Energy (MWh)	Flex to generate incremental energy output
3. Load shifting	Flex to shift energy 1. across time and 2. between different locations
4. Balancing services	Real time flex e.g. balancing, frequency response, fast reserve, inertia

The current asset menu offers no silver bullet… all have advantages & challenges

Asset type	1. Capacity	2. Energy	3. Load shifting	4. Balancing	Considerations & carbon footprint
Batteries					Very fast. Duration limitations. Net negative energy.
Interconnectors					Key to locational shift. Price dependent. Net zero energy.
Electrolysers & DSR					Duration limitations. Load shifting. Limited DSR resource.
Long duration storage					Flexible. Tech development & cost declines required for scale.
Engines (+ H2)					V flexible. Lower load factor. Require H2 retrofit / repowering.
CCGTs (+CCUS)					Flexible. Higher load factor. Difficult/expensive to decarbonise.

Darker blue indicates higher contribution towards 4 types of flex required.
Red indicates a net negative energy contribution, i.e. asset uses more electricity than it generates.

Flex investment options

	Batteries	Engines (+ H2)	Interconnector	CCGT (+ CCUS)	Merchant RES	Electrolysers
Target IRR	10-12%	10-12%	5-7%	10-12%	8-10%	Policy support dependent
Primary exposure	• Price shape & volatility	• Price shape & volatility	• Cross-border spreads	• Clean spark spread	• Power price levels	• Power price shape
Flexibility	• Ultra fast short duration flex for frequency and balancing	• Very flexible / fast short-medium duration energy	• Flex subject to market price signals (typically correlated)	• Medium to long duration energy • 2-6 hour lead time	• Flex focused on downward curtailment	• Both up & down flex (as long as storage backup)
Key downside risks	• Temporary overbuild • Other rapid flex • Slower RES rollout	• Decarbonisation e.g. H2 retrofit capex • RES price erosion • Battery build	• CO2 price floor removal • GB–NW European price convergence	• Faster RES deployment • Interconnectors & engines • CCUS costs	• Lower gas / CO2 prices • Price cannibalisation • Balancing risk	• Low renewable roll out • Slower decline in bottom 40% of prices
Downside protection	• Offtake contract floor / downside risk sharing • Inherent min. price shape & volatility	• 15 yr capacity contract • H2 conversion option (decarb risk)	• Ofgem cap & floor scheme (protects debt) • Potential to contract capacity	• 15 yr capacity contract • Structural requirement for gas until at least mid 2030s	• PPA / offtake contract • Capacity contracts (but high derating)	• CfD structure likely soon • Long-term offtake contract with industrials

Note: DSR & long duration storage not included in the table because these cover a range of technologies, returns & risks.

Route to market & offtake contracts

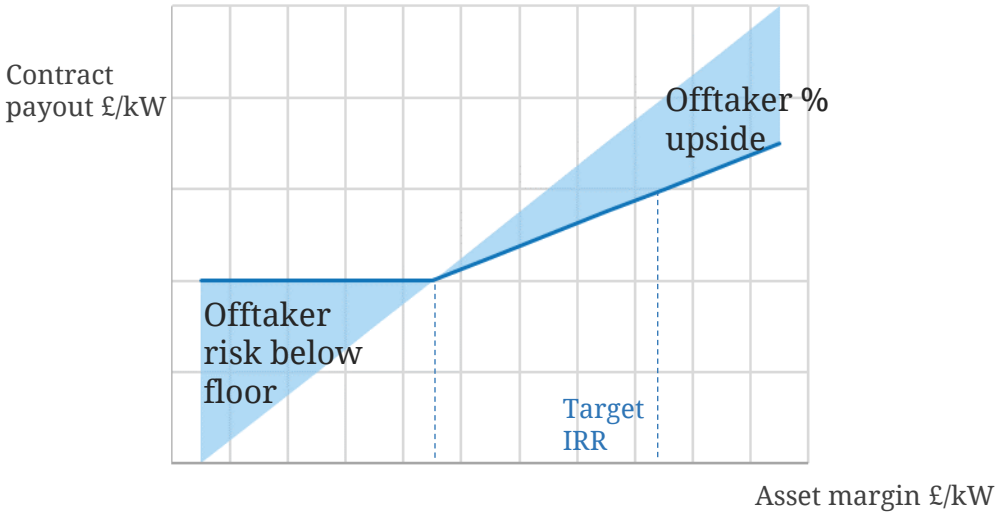
Offtake contracts underpin many flex investments

- Trading & optimisation capability translates directly into higher margins for flex assets (particularly batteries, engines & electrolysers).
- Many investors outsource this capability given overheads & economies of scale.
- But… there are many common pitfalls in the way offtake contracts are structured that result in 'value bleed' from asset to offtaker.
- Key issues include structure of downside protection, fees, margin share, incentives, risk alignment & 'asset hammering'.
- Hydrogen offtake contracts are evolving and are typically driven by complex local supply chain optimisation dynamics.

Offtake services are becoming more competitive

- Growing competition across service providers (e.g. EDF, Centrica, Orsted, Statkraft, Habitat).
- Floor levels are improving and contract durations are extending.
- Lenders are also increasingly comfortable with flex assets as long there is well structured downside protection.

Margin floor with upside sharing



Key offtake contract variables

- *Floor level & duration (if applicable)*
- *Fixed fee (to cover offtaker overheads)*
- *Tiered fee above (e.g. based on performance)*
- *Direct % share of margin (can be tiered)*

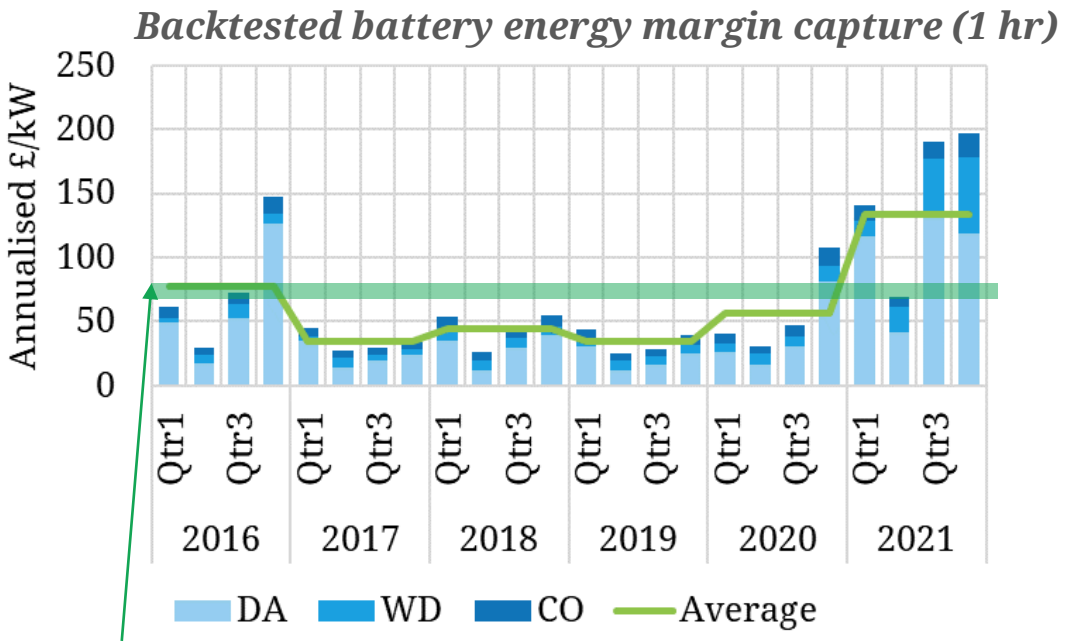
Case study 1: standalone battery project

Batteries currently earning big rents

- Battery margins are temporarily being dominated by new Dynamic Containment (DC) service ~150 £/kW/yr revenues (since Oct 2020).
- But more importantly, behind DC there has been structural growth in energy margins (from wholesale market & BM) – see chart.
- Energy margins have risen across 2020-22 to levels above 100 £/kW/yr, helped by covid shock & extreme price volatility.
- This is well above required returns to support investment.
- Structural market & policy drivers support the long term investment case for batteries (see Section A of this pack).

But important to understand risks of strong battery pipeline

- DC (& FFR) ancillary services are nearing saturation levels.
- This is set to erode ancillary returns to a discount to energy margins.
- There is a strong construction pipeline of batteries (3GW successful in latest T-4 auction)… but also significant supply chain constraints in sourcing cells & systems.
- Investment timing, risk management and exercise of site options are key to earning a sustainable return & protecting capital.



Source: Timera Energy battery backtest optimisation model

Case study 2: colocated battery project

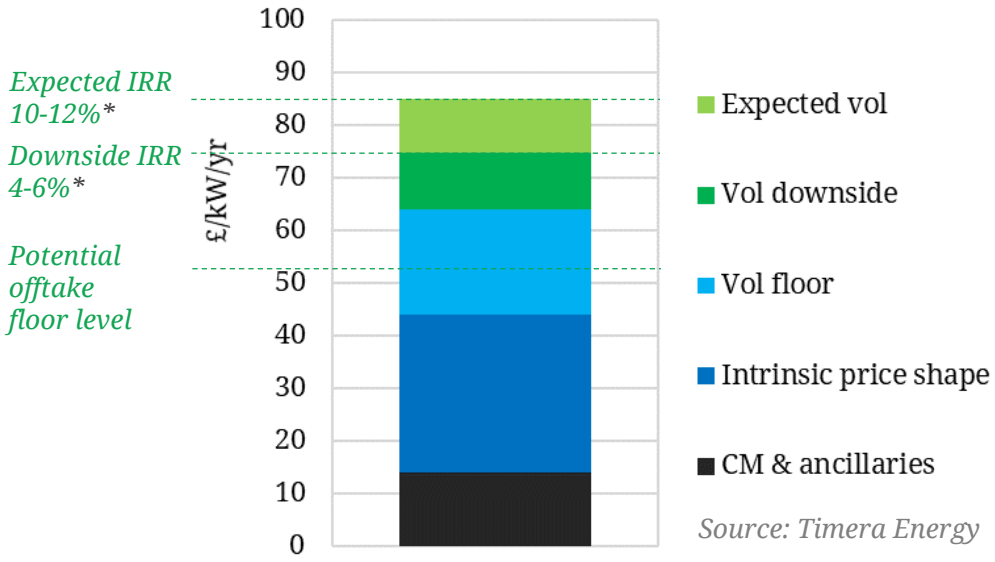
Genuine colocation benefits are often misunderstood

- Colocation of batteries with wind & solar projects can increase IRR by up to 2%, depending on location & configuration.
- Colocation margin gain is driven primarily by connection cost savings and avoided losses… not by using the battery to firm output.
- Tangible portfolio benefits come from colocation e.g.
    1. Diversifying RES cannibalisation risk
    2. Protecting downside to support financing.

Building a viable margin stack key

- Battery investment cases are different to RES & thermal assets because of a dependence on stacked interdependent margin streams.
- 15 yr capacity contracts @ 30.6 £/kW/yr in latest T-4 auction and ancillary revenues help stabilize margin at base of stack.
- Structural intraday price shape is also important downside protection.
- But evolution of market volatility and impact on margin is the key driver of (i) robust downside & (ii) viable expected return (see chart).
- Margin correlation with colocated wind or solar asset important driver of downside risk and access to financing.

Building a margin stack (2 hr duration)



Source: Timera Energy

Margin Tranche	Description
Volatility expected	Incremental value from 'expected' volatility case
Volatility downside	Incremental value from 'downside' volatility case
Volatility floor	Incremental value from inherent 'floor' level of volatility from RES/load swings
Intrinsic price shape	Value that can be captured against intrinsic price shape
CM & ancillaries	Ancillaries / network / capacity value streams

**Note: required return benchmarks are illustrateive unlevered IRRs based on long run average margins. Level of Downside IRR & volatility floor depend on analytical assumptions e.g. cell capex & capacity mix evolution.*

Case study 3: electrolyser & storage project

Building a viable investment case

- H2 is expensive given high input costs, driven by power prices
- So a successful investment case is driven by:
  - Maximising value of offtake, optimisation & grid services
  - Minimising cost of power input via integrated optimisation of electrolyser, H2 storage & offtake flex.
- Policy support is required to close the gap but is set to be rolled out across Europe in 2022-23.
- But an effective investment case & ability to finance will underpin access to policy support structures.

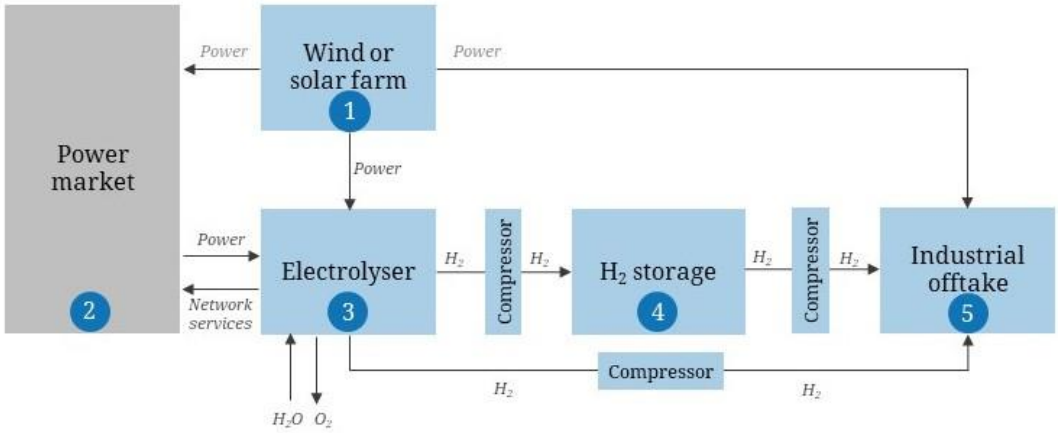
Electrolyser projects have strong parallels to batteries

1. Colocation of flexible assets with renewables (wind & solar)
2. Optimisation of asset flexibility in the power market
3. Revenue stacking e.g. from network & balancing services
4. Challenges of configuring, sizing & optimising storage
5. Similar trading & market access capability requirements.

5 drivers of a viable investment case

Driver	Description
Offtake	Well structured offtake with high value industrial user
Output flex	Electrolyser flex to source low cost power & provide grid services
Storage	Ability to store H2 to manage offtake & optimise costs/services
Optionality	Ability to optimise local supply chain optionality to add value
Financing	Offtake & downside revenue protection to support financing

Integrated green hydrogen energy system



Interdependent margin modelling components

1. Simulation of wind or solar profiles
2. Simulation of wholesale & balancing market prices
3. Optimisation of electrolyser production flexibility (vs power market, storage & offtake)
4. Optimisation of hydrogen storage (vs production & offtake)
5. Modelling of offtake uncertainty & constraints

Source: Timera Energy

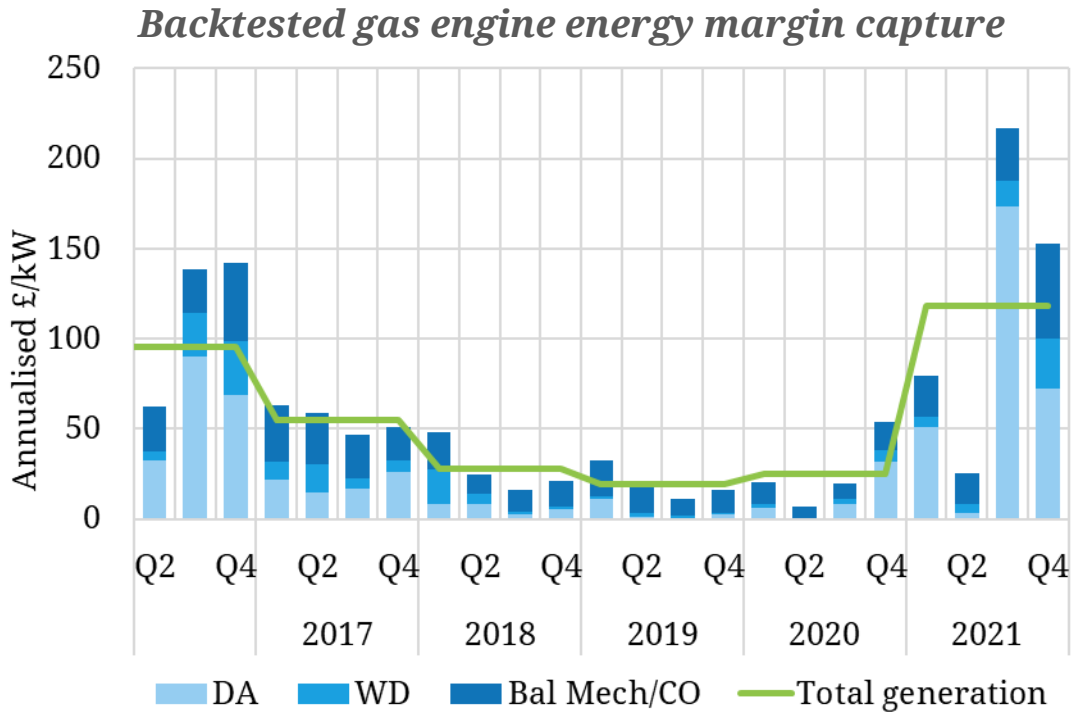
Case study 4: gas engine project

Engines needed to keep the lights on

- Gas engines are dominating CCGTs in the UK capacity market because they are more flexible & easier to decarbonize:
  - lower capex & opex
  - lower start costs & faster ramping
  - distribution connection benefits (additional revenue)
  - quicker payback, lower load factors & carbon footprint, lower cost to convert to hydrogen.
- Engines are better suited to providing balancing & reserve flex (multiple starts/ramps) to bridge the long duration flex gap until new low carbon technologies can be scaled.

Engine margin breakdown

- Margin stack underpinned by 15 yr capacity contracts (covering 40-50% of required return in latest capacity auction)
- Significant margin uplift from embedded benefits at right location & connection voltage.
- Energy margin (volatility harvesting) is still a key margin driver, with large increase in margins across 2020-22 (see chart).



Source: Timera Energy engine backtest optimisation model

Key investment case takeaways

The UK needs large investment in flexible assets including batteries, peakers, long duration storage, electrolysers & interconnectors.

Takeaway	Description
1. UK needs new flex fast	• Thermal asset closures are outpacing renewables growth, causing a rising UK flex deficit. • We estimate a requirement for at least 30GW of new flexible capacity by 2035.
2. Energy markets drive investment cases	• The primary driver of flexible asset returns is optimisation against wholesale & balancing prices. • Revenues are also underpinned by capacity contracts, but ancillary revenues face cannibalisation.
3. Structural drivers support flex value	• The UK's changing capacity mix & flex deficit are structurally supporting flex asset price signals. • Steepening supply stacks & intermittency are driving up price shape & volatility (evidence in 2020-22).
4. Flex complements RES portfolios	• Co-location of flex with RES assets is a big part of the solution... and can create tangible value uplift. • Flex can also diversify RES project risk and can improve renewable portfolio risk/return profiles.
5. Building a robust investment case	• Robust flex valuation relies on realistic optimisation of flex across co-dependent revenue streams. • This means stochastic modelling & explicit capture of trading strategy (to cover price uncertainty & imperfect foresight).

This is not just a UK story. The market & investment drivers in this pack apply to power markets across Europe.

About Timera

Timera offers expertise on value & risk in energy markets

Specialist energy consultancy

Focus on LNG and European gas & power assets

Extensive industry expertise

Practical knowledge from senior industry roles

Pragmatic commercial focus

Investment, value monetisation & market analysis

Strong client base

leading energy companies (producers, utilities, funds)

Leading industry blog

15,000+ regular readers, publications, conferences

Our clients include

What does Timera do?

Our asset class expertise

Power
- Asset valuation
- Commercial due diligence
- Transaction support
- Investment targeting
- Portfolio strategy

Hydrogen
- Electrolysers
- Hydrogen storage
- SMR + CCUS
- Offtake structures
- Supply chains

Gas & LNG
- Supply contracts
- Regas & liquefaction
- Shipping
- Storage & pipelines
- Portfolios

Our services

Investment
- Asset valuation
- Commercial due diligence
- Transaction support
- Investment targeting
- Portfolio strategy

Value Management
- Asset monetisation
- Contracting & optimisation
- Market access/offtake
- Trading & risk management
- Capability development

Market Analysis
- S&D analysis
- Stochastic modelling
- Price & volatility analysis
- LNG-gas-power modelling
- Flex value drivers

Modelling flex asset margins

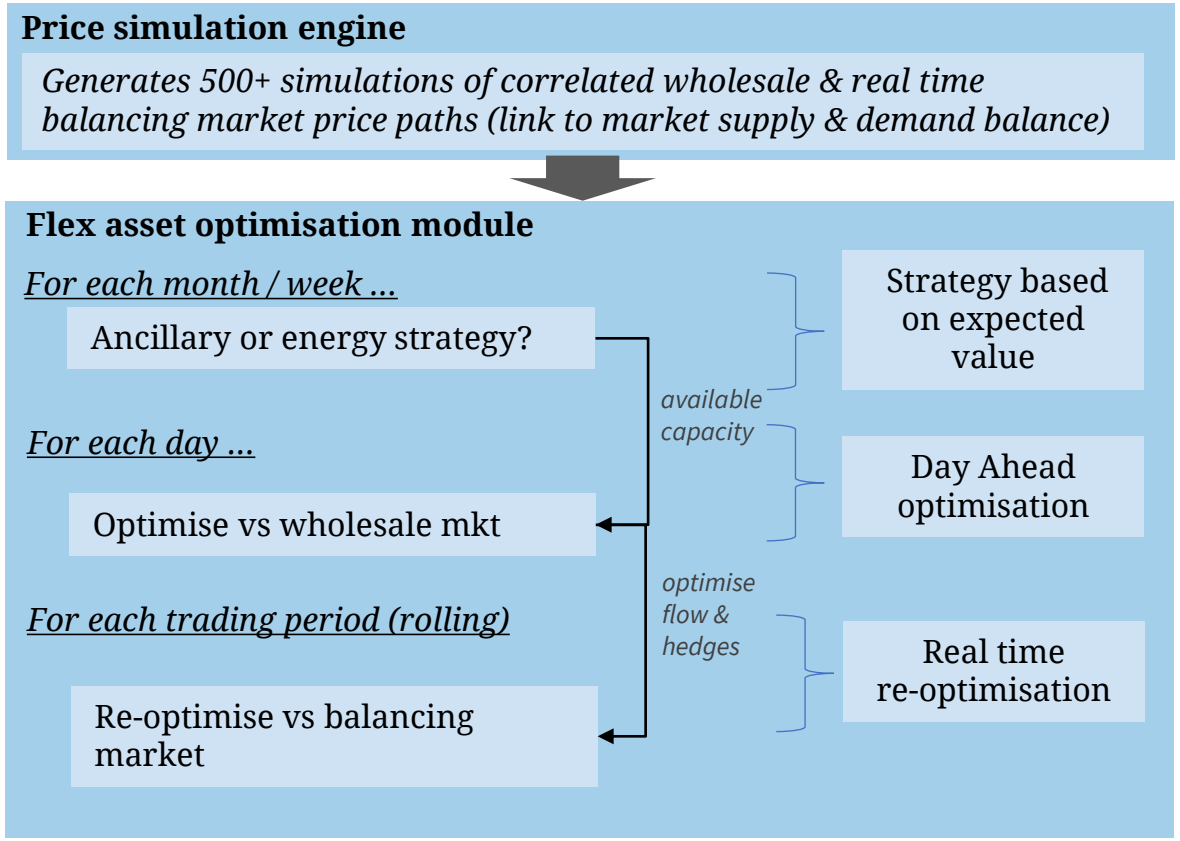
Stochastic modelling is the only way to value flex

- We have developed an in-house flexible asset margin modelling framework which draws on existing stochastic techniques for dispatching flex assets (e.g. batteries, hydro, peakers & electrolysers).
- Our approach is consistent with those used by established flex asset operators (e.g. EDF, Habitat, Statkraft, Centrica).
- This allows us to project realistic asset margins which capture the actual asset trading & optimisation strategy.

Methodology overview

- Key inputs: capacity, efficiency, variable costs, flex constraints.
- Key outputs:
  - Wholesale, balancing & ancillary margin numbers
  - Variable costs (e.g. charges, losses) & operational / cycling data.
- Key asset optimisation steps are illustrated in the diagram.
- Across each time step, the model reflects the practical decision making process that a trader faces when dispatching a live asset.
- Importantly, we replicate both the trader's imperfect foresight & the costs associated with re-balancing the asset.

Timera's flex asset margin model summary



Timera power team members

Our team members have extensive senior industry experience and practical commercial knowledge.

David Stokes: Managing Director

20+ years energy/commodity market experience
Expert in investment/monetization of flex power assets
Industry roles with Origin, Williams, JP Morgan

Olly Spinks: Managing Director

20+ years energy industry experience
Expert in flexible power asset valuation
Ran BP's power, gas & LNG commercial analytics function

Steven Coppack: Director

8 years energy industry experience (EDF, Total)
Trading, optimisation and fundamental analysis expert
Analysis, operations & trading industry background

Rosie Read: Director

10 years energy industry experience (Meridian)
Storage optimisation & commercial analysis expert
Analysis, strategy & power trading industry background

Nick Perry: Senior Advisor

30+ years industry experience (Enron, Amoco)
Expert in commercial & risk management strategy
Board level experience (Enron Europe, Teesside Power)

David Duncan: Senior Analyst

4 years front office industry experience (RWE Trading)
Strong in commercial analytics & portfolio optimisation
Portfolio hedging & optimisation at RWE

Contact us

David Stokes david.stokes@timera-energy.com
Managing Director +44 (0) 7957 656 337

Steven Coppack steven.coppack@timera-energy.com
Power Director +44 (0) 7817 916 581

Address: L12, 30 Crown Pl, London, EC2A 4ES, GB
Tel: +44 (0) 20 7965 4541

www.timera-energy.com